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Effects of Climate Change on Social Infrastructure in a Developing Nation : The Nigeria Perspective

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ABSTRACT

The World over, a nation's state of infrastructure remains a major indicator of its developmental status; developed or less developed. Physical developmental processes are considered as inducing climate change, which in turn adversely exposes humanity to significant risk. In this study, the influence of climate change on social infrastructure and socioeconomic growth in a less developed country (LDC), like Nigeria, was examined. Nigeria currently is the fastest urbanizing, most populous and largest economy in Sub-Saharan Africa. Infrastructural developments in Nigeria since independence in 1960, till date, are based on low energy efficient technologies. Empirical observations signpost a nexus between climate change and social infrastructure and its impacts on socioeconomic growth and development. Consequently, based on the United Nations (UN) Sustainable Development Goals (SDGs) agenda, this paper examines the link between climate change and infrastructural development. Furthermore, the study presents practical strategies required to mitigate the potential impacts of climate change on current and future infrastructural developments. The solutions proffered in the paper are anchored on Development, Adaptation and Mitigation (DAM) approach and Climate Change Action Plan (CCAP). The findings demonstrated that climate change not only affects social infrastructural development but also the socio-economic growth and sustainable development especially in Less Developing Countries (LDCs) like Nigeria. The mitigation and abatement strategy recommended to reduce GHG's emissions is a substantial investment in research and development (R&D) of sustainable materials and alternative technologies like construction materials, solar, wind and hydropower. This is with a view to increasing the life cycle of both the existing and new infrastructure through effective planning, design, construction and maintenance.

Keywords: Climate Change, Social Infrastructure, Less Developing Countries (LDCs), Sustainable Development Goals (SDGs), Nigeria.

I. INTRODUCTION

The United Nations (UN) defines developing countries as countries characterised by moderate to low Human Development Index (HDI) [1]. The HDI is a complex measure of the life expectancy, literacy levels, and economic indicators used to rank nations into four (4) tiers namely; low, Medium, High and Very High of human development. According to this index developed by the economists *Amartya Sen* and *Mahbub ul Haq*, developing nations are typically considered to be at low-medium levels of human development [2, 3]. Consequently, the concept of development is essential for comparing developing and developed countries. The United Nations Development Program's (UNDP) Human Development Report (HDR, 2015) describes human development as the growth of rights, freedoms and capabilities of

individuals within the society to lead meaningful lives [4]. For citizens of developing nations, development generally means the struggle to meet basic needs such as good health and sanitation, water, housing, and other infrastructure severely lacking or non-existent in their environment. Therefore, developing countries are also referred to as less developed (LDC) or underdeveloped countries (UDC) due to high levels of poverty, and illiteracy, along with low living standards, poor infrastructure and industrial base [4, 5]. The underlined dynamics ultimately highlight the significant socioeconomic and geopolitical differences between developed and developing countries. More so, the concept of development is significantly influenced by the existence of modern physical and institutional infrastructure complemented by continuous, sustainable socioeconomic systems required for growth, development and improved standards of living. In view of the importance of infrastructure to development, especially in LDCs where it is lacking, the United Nations (UN) and signatory countries on September 25, 2015, adopted 17 goals aimed at ending poverty, protecting the planet, and ensuring prosperity as part of a new agenda for sustainable development. These set of goals are collectively termed the Sustainable Development Goals (SDGs), each with specific targets to be achieved in 15 years. Specifically, Goal 9 (nine) of the SDGs initiative seeks to stimulate the development of resilient infrastructure, sustainable industrialization and technological innovation [4, 5]. This is against the backdrop of numerous challenges facing developing nations particularly in area of social infrastructure and human development. Some of the challenges include rampant corruption, over population, a weak judiciary, uncontrolled migration, housing shortages, rising deforestation, energy crises, land degradation, rigid land laws, and climate change [6-9]. These challenges can be categorized broadly into socioeconomic, technological, environmental and geopolitical factors. Amongst the outlined factors, climate change is considered the greatest global threat to the existence of mankind and its generations. Climate change directly affects the lives of millions of people around the planet due to changing weather patterns, rising sea levels and extreme weather conditions [9]. This scenario, in turn, affects the socioeconomic and environmental wellbeing of people and planet. With the rising levels of anthropogenic greenhouse gas (GHGs) emissions, the effect of climate change is set to soar with disruptions mainly in developing nations [10, 11].

Consequently, the aim of this paper is to highlight the effects of climate change on the socio-economic growth and sustainable development in developing countries. Due to the wide scope of the study, the focus will be on climate change and infrastructural development in Nigeria - Africa's most populous country, fastest urbanizing and largest economy. This is based on the country's Vision 20: 2020 strategy to become one of the top 20 largest economies in the world by the year 2020. However, analysts posit that the nation's ambition will result in increased GHG emissions, global warming, climate change and ultimately damage to the environment [12]. Therefore, this study highlights and proposes potential remedying strategies for climate change mitigation and abatement to safeguarding current and future infrastructure in Nigeria.

II. METHODS AND MATERIAL

1. Climate Change and Sustainable Development Goals

According to the Intergovernmental Panel on Climate Change (IPCC), global temperatures have increased by 0.85 °C from 1880 to 2016. Figure 1 presents data illustrating the change in global average land-ocean temperatures [13].

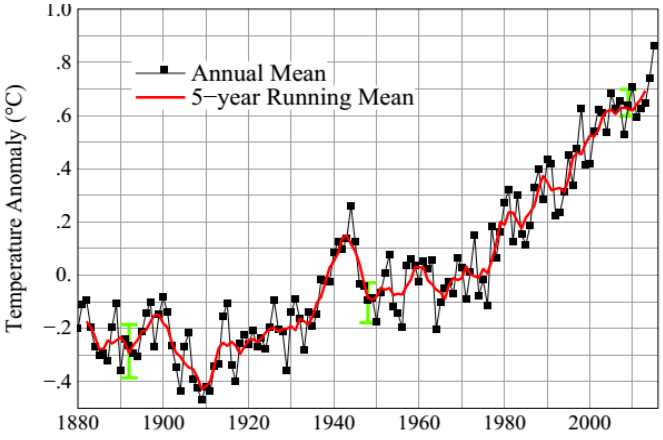
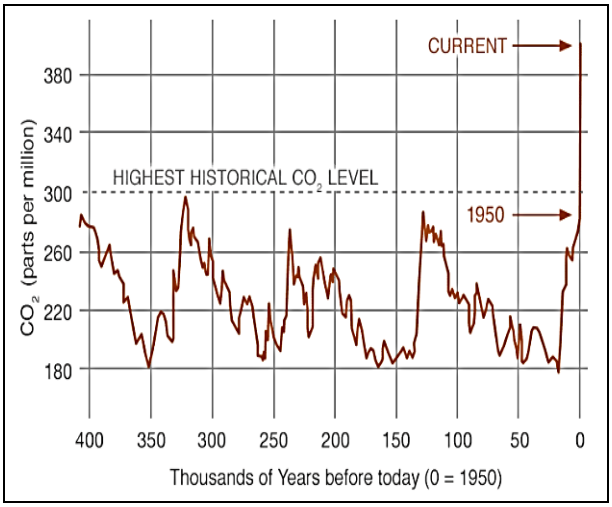
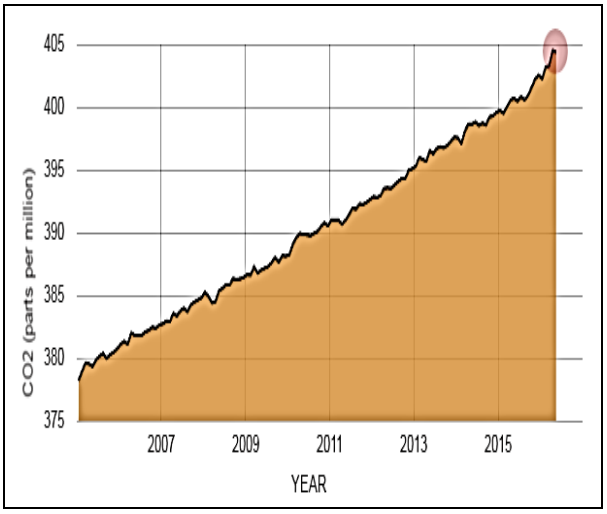


Figure 1: Global Average Temperatures from 1880-2016 *[13]*.



(a)



(b)

Figure 2 : Global Rise in CO_2 emissions [14]

The sharp rises in global temperature occasioned by increased emissions of GHGs such as CO_2 have resulted in global climate change. Consequently, having been identified as the singular largest cause, GHGs, there is need to urgently stimulate the transition from fossil fuels to low-carbon technologies and green economy. Figure 2 presents an overview of the average rise in CO_2 emissions over the same period with the steepest rises occurring between 2005 and 2016. Consequently, analysts opine global inaction may lead to crises in developing countries. Empirical evidence currently surmises that rising sea levels, poor harvests, and the numerous natural disasters over the years can be attributed to climate change [11]. Accordingly, the United Nations (UN) and signatory parties to the SDGs envisage that universal collaboration on climate change mitigation will help prevent the potential effects of climate change in the future [4, 15]. In furtherance of these objectives, goal 13 aims to support adaptive capacity hazards and natural disasters resulting from climate change. This can be achieved through the integration of policies, strategies and policies aimed at improving institutional capacity, global education and awareness campaigns. In view of this, the United Nations Framework Convention on Climate Change (UNFCCC) plans to invest $100 billion annually by 2020 to fund climate change mitigation, impact reduction, adaptation and early warning systems for the future [9]. The establishment of these measures will no doubt, significantly stimulate sustainable development in LDCs of the world.

I. INFRASTRUCTURAL DEVELOPMENT AND SUSTAINABLE DEVELOPMENT GOALS

The development of social infrastructure is a core tenet of the United Nations (UN) Sustainable Development goals initiative. As revealed in Goal 9, the UN aims to build resilient infrastructure, promote sustainable industrialization and foster innovation for the future of humanity. The institution of this goal is based on the premise that investments in social infrastructure which includes roads, transportation, water irrigation systems, energy and information and communication technology (ICT) are vital for growth and development of future societies.

Analysts have opined that investments in social infrastructure are paramount for stimulating, developing and maintaining livelihoods, productivity as well as healthy livings standards of individuals within any society. Furthermore, social infrastructure is an important yardstick and catalyst for technological innovations, scientific discoveries and sustainable solutions needed for industrialization [9]. However, many developing nations lack the basic infrastructure required to boost trade, investments, and industrial production [16, 17]. For example, over 2 billion people in the developing world lack access to modern energy services, basic sanitation, and access to clean water. Furthermore, large proportions of the Asian and African population lack basic IT and Telecommunications facilities [4, 15, 18]. In addition, weak infrastructure is considered one of the greatest impediments to socioeconomic growth and sustainable development [19]. This has been attributed to a number of factors such weak investment

environment, rampant corruption, political instability and more recently climate change.

The analysts at the African Development Bank (ADB), opine that climate change will aggravate the prevailing infrastructure deficiency on the continent prompting the need for reforms [20]. The realization of social, economic and political goals in any society is dependent on timely access to quality infrastructure [21]. This is known to improve access to markets, jobs creation, living standards, information gathering, access to healthcare, literacy levels and the security of lives and property. Consequently, the UN has set out to achieve a number of targets under Goal of 9 of the SDGs.

Therefore, Goal 9 aims to ensure the development of quality, reliable and sustainable social infrastructure for growth and development. This will foster trans-border trade and catalyze human and capital development globally. Furthermore, Goal 9 is intended to promote sustainable industrialization, increase access to finance, R&D innovations, efficient resource utilization, and environmentally sustainable practices for growth and development by the year 2030. According to the World Bank, LDCs like Nigeria can achieve this by investing in four key areas like agriculture and land use, oil and gas, power, and transport sectors. This will ensure the sustainable action towards low carbon development (LCD), reduced GHG emissions and climate change mitigation as presented in Figure 3. [12].

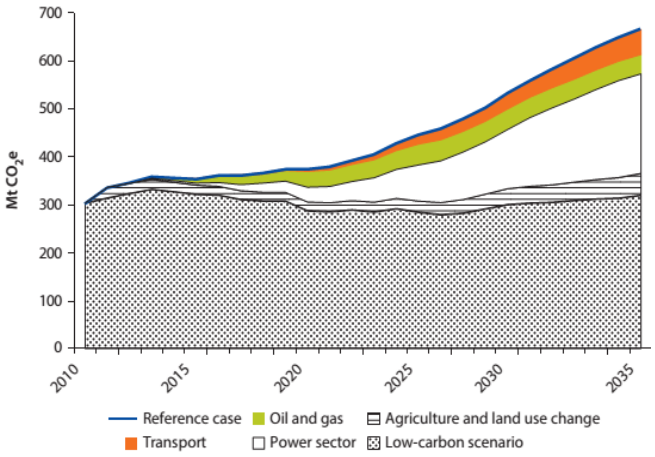


Figure 3 : Low-carbon scenario: mitigation potential and residual emissions by sector *[12]*.

The projections indicate that adoption of LCD strategies will stabilize emission to nearly 300 million metric tons of CO_2 [12]. The estimated savings from the four key sectors from 2010 to 2035 as outlined in Table 1.

Table 1: Sectoral Savings on Emissions in Nigeria [12]

Sector	National cost, % of GDP	Net national benefits, % of GDP	Cumulative GHG abatement, billion tons CO_2
Agriculture	0.04	0.23	0.65
Oil and gas	0.11	0.26	0.75
Power	0.70	1.40	1.90
Transport	-	-	0.45
Total	0.85	1.89	3.77

The data in Table 1 indicate that the proposed strategies will curb potential emission by 3.8 billion Mt CO2 over the quarter of a century [12]. Furthermore, it is believed that the accruing benefits will also facilitate the sustainable development of robust infrastructure in LDCs by improved access to practical financial and technological support. Technological support encompasses modern technologies for affordable access to ICTs and the internet in LDCs by 2020 [9].

III. RESULTS AND DISCUSSION

1. Climate change on infrastructural development in LDCS

The climate change and infrastructural development (CCID) nexus is paramount to the realization of goals 9 and 13 aimed at sustainable growth and development in LDCs. As the largest economy and most populous African nation, it is important to identify, highlight and evaluate the potential effects of climate change on infrastructural development in Nigeria. Consequently, the effects of climate change on infrastructure will be evaluated based on its influence on existing infrastructure, development of new and future infrastructure in Nigeria.

a. Existing Infrastructure In Nigeria And Climate Change

The existing infrastructure in Nigeria and most LDCs were developed based on low energy efficient technologies with little or no consideration for climate change. However, rising temperatures and greater risk of natural hazards and disasters due to climate change require urgent remedial action. According to *Chinowsky et al.*, [22] failure to either consider or

comply with climate change will adversely impact on existing infrastructure. In tropical countries like Nigeria, incidences of rising temperature, disasters and environmental challenges due to climate change will potentially result in increased cost of design, construction and maintenance of infrastructure. Consequently, roads, buildings, and social infrastructure will need modifications based on changes to climate in the future. This is with the intent of ultimately reducing GHGs emissions, lessening the vulnerability of existing infrastructure to climate change and enhances environmental wellbeing.

Consequently, *Chinowsky et al.,* [22] propose a proactive approach to understanding and addressing climate change in existing infrastructure. This can be achieved by incorporating alternative/renewable technologies, sustainable materials and building practices during maintenance and the life span of current infrastructure [23-25]. However, a substantial investment in alternative technologies like solar, wind for mitigating GHGs emissions form of energy consumption is required [24, 26]. Hence, substantial R&D into sustainable materials is needed with a view to reducing degradation and thus increase the life span of infrastructure [27]. The potential cost of climate-proof technologies for Africa according to the World Bank will cost nearly US$93 billion. The largest proportion of which will be allocated to energy while other low carbon, sustainable technologies accounting for the remainder [20].

b. New-Future Infrastructures And Climate Change

The need to ensure the future sustainability of infrastructure requires the integration of climate proof technologies into the planning, design, and construction process. Consequently, new standards for assessing the life cycle, risk assessment and form functionality of new infrastructure must be implemented accordingly. In addition, the governments of LDCs need to establish modalities such as early warning technologies and remediation strategies. This will help cater for unforeseen hazards and natural disasters such as climate change induced floods that directly affect social infrastructure such as roads, bridges, energy, water utilities.

As a result, investments in R&D for low carbon energy source, energy efficient and climate-proof technologies are required for future developments. This is fundamental to the goal of mitigating climate change and ensuring socio-economic growth and sustainable development. In the Nigerian context, climate change will potentially influence the overall socio-economic, environmental and geopolitical landscape of infrastructural development. The development, adoption and implementation of climate change policies will significantly revamp the infrastructure landscape. It will stimulate the revision of policies, curricula, R&D, standards as well as the social orientation towards climate change in the future.

2. Potential Solutions To Climate Change On Infrastructural Development

The potential solutions to the impacts of climate change on the development of infrastructure will be evaluated based on a novel methodology termed the Development, Adaptation, and Mitigation- DAM. The concept is anchored on Climate Change and Infrastructure Development (CCID) nexus proposed by the African Development Bank (ADB) [20]. According to the concept, the development, adaption and mitigation of new, existing and future infrastructure are strategic for climate change abatement.

The development of new infrastructure is required to cater for the present and future generations. With the rapidly geometric global population, explosive rural-urban migration driving unprecedented pressure on resources, only by balancing the dynamics of infrastructural planning and development can the effects of climate change be minimized.

The development of new infrastructure, therefore, needs to incorporate low carbon technologies [28], indigenous sustainable materials [29, 30], and techniques such as kinetic architecture, building information modelling and alternative building technologies like the industrialized building systems [31-34]. In addition, existing infrastructures must be adapted. The process of adapting existing infrastructure is a necessary strategy for safeguarding the long-term sustainability and reducing societal pressures. This approach will reduce the risk of structural and institutional failures [20].

Furthermore, strengthening the adaptive capacity of current infrastructure not only caters for the potential dangers of climate change but as well ensures their attaining maximum life span. Similarly, mitigation strategies for protecting existing and planning future social infrastructure are of paramount importance to minimize the effect of climate change. This will require long-term human capital and material resources in the smart infrastructure to immediately mitigate and eliminate future effects of climate change [20, 35, 36]. Consequently, high emissions prone social infrastructures such as energy, waste, water, agroforestry and transportation systems require greater consideration.

However, due to the policy specificity and structural rigidity of the DAM approach, the World Bank Group-2016 devised the Climate Change Action Plan (CCAP). The approach seeks to tackle the challenges of global warming and climate change using a holistic approach. Consequently, the framework policies of CCAP aim to speed up action on climate change mitigation based on five core objectives namely [37];

- *Implementation,*
- *Convergence,*
- *Maximization,*
- *Resilience,*
- *Transformation.*

According to the World Bank, the ***implementation*** aspect of the CCAP is aimed at planning, promoting and partnering with nations and multinational companies to actualize global climate change policies and programmes in the future. The ***convergence*** aspect will seek to integrate the banks' climate change and developmental strategies with host country policies and programmes. Equally, the ***Maximization*** goal aims to prioritize the WB's policy frameworks and objectives with impact at scale by mobilizing private finance, investments and policy guidance to national governments and their programmes on climate change. The ***Resilience*** goal seeks to merge adaptation and flexibility by rebalancing the bank's portfolio and global climate change models. Lastly, the ***Transformation*** agenda seeks to make significant impacts on the quest to achieve global climate change commitments by changing the status quo [37].

The objectives can be narrowed down to four important priorities namely;

- Supporting the transformation policies of nations and their institutions,
- Leverage private and public resources towards developmental goals,
- Scaling up global actions aimed at mitigating climate change,
- Prioritizing the internal processes and collaboration between Climate action partners.

In conclusion, the CCAP is a demonstration of the World Bank's commitment to climate change in the near future. It presents the bank's strategic investments in scaling up and integrating global climate action with its developmental policies in countries around the globe.

IV. CONCLUSION

The paper examined the effect of climate change on social infrastructure development in Nigeria as a less developed country. The paper highlighted the nexus between climate change and infrastructural development and its influence on the realization of the United Nations (UN) Sustainable Development Goals (SDGs) agenda. Furthermore, the findings demonstrated that effects of climate change are not limited to social infrastructural development but also adversely impact on the socio-economic growth and sustainable development in LDCs like Nigeria. Lastly, the paper presented practical solutions to the potential effects of climate change on the current and future infrastructural landscape in Nigeria.

V. REFERENCES

[1] United Nations Development Programme (UNDP). (2016, 02 March). *A new sustainable development agenda*. Available: http://bit.ly/1Oj6TBV

[2] A. Sen, "The ends and means of development," *Development as freedom*, vol. 1, pp. 35-53, 1999.

[3] M. U. Haq, "Reflections on human development " Human Development Report Office (HDRO), United Nations Development Programme (UNDP)1994.

[4] UNDP. (2015). *Human Development Reports Work for Human Development (HDP, 2015)*. Available: www.hdr.undp.org/en/2015-report

[5] EPI. (2010). *What is a Developing Country?* . Available: http://bit.ly/1RHJYlH
[6] A. N. Baba, M. I. Achoba, and E. O. Ojoko, "Sustainable Land Use and Forest Management for Socioeconomic Growth and Development in Nigeria," *International Journal of Scientific Research in Science, Engineering and Technology*, vol. 2, pp. 572-577, 2016.
[7] A. S. Barau, R. Maconachie, A. Ludin, and A. Abdulhamid, "Urban morphology dynamics and environmental change in Kano, Nigeria," *Land Use Policy*, vol. 42, pp. 307-317, 2015.
[8] Y. A. Dodo, R. Nafida, A. Zakari, A. S. Elnafaty, B. B. Nyakuma, and F. M. Bashir, "Attaining Points for Certification of Green Building through Choice of Paint," *Chemical Engineering Transactions*, vol. 45, pp. 1879-1884, 2015.
[9] United Nations (UN). (2016, 14.02.2016). *Sustainable Development Goals (SDGs)*. Available: http://bit.ly/1IqICxS
[10] W. N. Adger, S. Huq, K. Brown, D. Conway, and M. Hulme, "Adaptation to climate change in the developing world," *Progress in development studies*, vol. 3, pp. 179-195, 2003.
[11] S. Huq, H. Reid, M. Konate, A. Rahman, Y. Sokona, and F. Crick, "Mainstreaming adaptation to climate change in least developed countries (LDCs)," *Climate Policy*, vol. 4, pp. 25-43, 2004.
[12] R. Cervigni, J. A. Rogers, and M. Henrion, *Low-Carbon Development: Opportunities for Nigeria*: World Bank Publications, 2013.
[13] J. Hansen, R. Ruedy, M. Sato, and K. Lo, "Global surface temperature change," *Reviews of Geophysics*, vol. 48, 2010.
[14] National Oceanic and Atmospheric Administration (NOAA). (2016). *Global Rise in CO2 emissions from 2005 and 2016*. Available: http://climate.nasa.gov/vital-signs/carbon-dioxide/
[15] United Nations Development Programme (UNDP). (2016, 02.03). *Sustainable Development Goals (SDGs)*. Available: http://bit.ly/202GssO
[16] A. Binagwaho and J. D. Sachs, "Investing in development: a practical plan to achieve the Millennium Development Goals," Earthscan; Millennium Project2005.
[17] S. Adams, "Foreign direct investment, domestic investment, and economic growth in Sub-Saharan Africa," *Journal of Policy Modeling*, vol. 31, pp. 939-949, 2009.
[18] United Nations, "Millennium Development Goals Report," United Nations, New York, USA2015.
[19] S. Bougheas, P. O. Demetriades, and E. L. Morgenroth, "Infrastructure, transport costs and trade," *Journal of International Economics*, vol. 47, pp. 169-189, 1999.
[20] African Development Bank (ADB), " Acting on Climate Change for Sustainable Development in Africa, in Seventh African Development Forum: Climate Change and Infrastructure Development, ," African Development Bank (ADB)2010.
[21] United Nations Development Programme (UNDP), "What is human development?," 2015.
[22] P. S. Chinowsky, A. E. Schweikert, N. L. Strzepek, K. R. Strzepek, and K. P. Kwiatkowski, "Infrastructure and climate change: Impacts and adaptations for South Africa," WIDER Working Paper 9292305719, 2012.
[23] Y. A. Dodo, M. Zin Kandar, D. Remaz Ossen, J. D. Jibril, A. Haladu Bornoma, and A. Ibrahim Abubakar, "Importance of a View Window in Rating Green Office Buildings," in *Advanced Materials Research*, 2013, pp. 180-183.
[24] A. S. Isa, Y. A. Dodo, H. Ojobo, and I. A. Alkali, "Deployment Of Smart Technologies For Improving Energy Efficiency In Office Buildings In Nigeria," *Journal of Multidisciplinary Engineering Science and Technology*, vol. 3, 2016.
[25] Y. A. Dodo, M. H. Ahmad, M. Dodo, F. M. Bashir, and S. A. Shika, "Lessons from Sukur Vernacular Architecture: A Building Material Perspective," in *Advanced Materials Research*, 2014, pp. 207-210.
[26] A. Y. Muhammad, M. G. Abdullahi, and N. Y. Mohammed, "Critical Factors Affecting The Development And Diffusion Of Renewable Energy Technologies (RETS) In Nigeria," *Journal of Multidisciplinary Engineering Science and Technology*, vol. 2, pp. 2260-2263, 2015.
[27] T. G. Nijland, O. C. Adan, R. P. van Hees, and B. D. van Etten, "Evaluation of the effects of

expected climate change on the durability of building materials with suggestions for adaptation," *Heron*, vol. 54, pp. 37-48, 2009.
[28] A. Kawuwa, A. Sani, S. Mustapha, and D. Ishaku, "Development of Strategies for Sustainable Energy Efficient Building Codes in Nigeria," *International Journal of Scinetific and Research Publications*, vol. 5, pp. 1-7, 2015.
[29] A. Olotuah, "Recourse to earth for low-cost housing in Nigeria," *Building and Environment*, vol. 37, pp. 123-129, 2002.
[30] Y. A. Dodo, M. Z. Kandar, M. Hamid, R. T. Ahar, and H. I. Ojobo, "Creating awareness on harnessing the potentials of wood as a sustainable construction material in Nigeria," in *4th International Symposium of Indonesian Wood Research Society* Makassar, Indonesia., 2012.
[31] Y. Arayici, "Towards building information modelling for existing structures," *Structural Survey*, vol. 26, pp. 210-222, 2008.
[32] B. V. Reddy and K. Jagadish, "Embodied energy of common and alternative building materials and technologies," *Energy and Buildings*, vol. 35, pp. 129-137, 2003.
[33] L. Roma, "Climate variability, environment change and food security nexus in Nigeria," *Journal of Human Ecology*, vol. 26, pp. 107-121, 2009.
[34] S. H. Wail, A. M. Yusof, S. Ismail, and C. A. Ng, "Exploring Success Factors of Social Infrastructure Projects in Malaysia," *International Journal of Engineering Business Management*, vol. 5, pp. 1-9, 2013.
[35] E. O. Ojoko, M. H. Osman, A. B. Rahman, W. S. Omar, and O. Ojoko., "Critical Success Factors of Industrialized Building System Implementation in Nigerian Mass Housing Projects, ," in *Proceedings of the 2nd International Conference on Science, Engineering and Social Sciences*, Johor Bahru, Malaysia, 2016, pp. 254-255.
[36] E. O. Ojoko, H. O. Abubakar, O. Ojoko, and E. O. Ikpe, "Sustainable Housing Development In Nigeria: Prospects and Challenges," *Journal of Multidisciplinary Engineering Science and Technology*, vol. 3, pp. 4851-4860, 2016.
[37] World Bank Group (WBG). (2016, 30th June, 2016). *Climate Change Action Plan (CCAP)* Available: http://bit.ly/2974nrD